THE *ROSAURA* EXPEDITION
1937-38
CHAETOGNATHA

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By JOHN S. COLMAN

INTRODUCTION

Genus ***SAGITTA*** Quoy & Gaimard, 1827

Group	Species	Number	Number of hauls
(a) "*Friderici*"	1. *Sagitta friderici* Ritter-Záhony, 1911	2	2
	2. *S. tenuis* Conant, 1896	177	2
(b) "*Bipunctata*"	3. *S. bipunctata* Quoy & Gaimard, 1827	6	5
	4. *S. elegans* Verrill, 1873	42	2
	5. *S. robusta* Doncaster, 1902	14	3
(c) "*Serratodentata*"	6. *S. serratodentata* Krohn, 1853	95	4
(d) "*Lyra*"	7. *S. lyra* Krohn, 1853	110	11
	8. *S. maxima* (Conant, 1896)	167	10
(e) "*Hexaptera*"	9. *S. hexaptera* d'Orbigny, 1843	299	11
	10. *S. decipiens* Fowler, 1905	29	7
(f) "*Enflata*"	11. *S. enflata* Grassi, 1881	141	13
(g) "*Planctonis*"	12. *S. planctonis* Steinhaus, 1896	12	2
	13. *S. zetesios* Fowler, 1905	84	10
(h) Ungrouped	14. *S. neglecta* Aida, 1897	7	5
	15. *S. pulchra* Doncaster, 1902	2	1
	16. *S. macrocephala* Fowler, 1905	107	7

Genus ***PTEROSAGITTA*** Costa, 1869

17. *Pterosagitta draco* (Krohn, 1853)	45	9

Genus ***KROHNITTA*** Ritter-Záhony, 1910

18. *Krohnitta subtilis* (Grassi, 1881)	11	5

Genus ***EUKROHNIA*** Ritter-Záhony, 1909

19. *Eukrohnia hamata* (Möbius, 1875)	204	5
20. *E. fowleri* Ritter-Záhony, 1909	277	9
Total	1831	19

THIS collection contains 1,831 individuals of 20 species (16 of *Sagitta*, 1 *Pterosagitta*, 1 *Krohnitta* and 2 *Eukrohnia*) taken in 19 hauls. In the above list the order of species and the groups of *Sagitta* are based on Furnestin (1957); I have added the group "*planctonis*" (see David, 1956). The most distinct of these groups, such as "*lyra*" and "*planctonis*", are undoubtedly of some value in making minor distinctions within the genus *Sagitta*, but no useful purpose would be served by raising them to subgeneric rank ; it would be only a matter of time before attempts would be made to raise such subgenera to generic status, and this would only create confusion.

The full list of stations on the *Rosaura* expedition is given in Colman (1954).

I am grateful to Dr. J. H. Fraser, Dr. E. L. Pierce and Mr. P. M. David for much helpful and interesting correspondence. Dr. Pierce and Mr. David both examined some of my specimens and sent me some of theirs, and Dr. Fraser kindly read through the typescript. I also wish to thank Dr. Ben Dawes for examining the parasites.

Before the catches of chaetognaths are discussed in detail, the limitations of this collection should be pointed out. All the catches were made with open nets, so that in the case of the deep hauls there is no telling in most cases from what depth the specimens came. With one exception, all the deep hauls were made with a 2-metre stramin net ; the stramin mesh is too coarse for the reliable sampling of the smaller and more slender species, such as *S. friderici*, *S. tenuis*, *S. bipunctata*, *S. robusta*, *S. serratodentata*, *S. decipiens*, *S. neglecta*, *S. pulchra*, *P. draco* and *K. subtilis*, all of which were probably under-represented in the deep hauls.

Each deep haul lasted about two hours, and each catch contained up to hundreds of fish and scores of molluscs, crustacea etc., many of which were larger than the chaetognaths. Sorting was done single-handed ; all that I was able to do was to pick out specimens of about 30 different categories in the various phyla until I did not appear to be finding anything new. It is hoped that this procedure will give some idea of the relative abundance at each station of at any rate the larger chaetognaths, but I do not think that I sampled adequately such smaller species as the stramin net was able to retain.

Within the chaetognaths themselves the only sorting done on the spot was between red and colourless forms. All of *Sagitta macrocephala* and *Eukrohnia fowleri* were red, and there were occasional red individuals of *S. enflata*, *S. zetesios* and *Pterosagitta draco*.

Owing to the length of the deep hauls, many of the specimens are more or less damaged ; this is much less true of the short hauls made near the surface with the small silk townet, which confirms the observation of David (1955, p. 240). In addition, all my samples (after killing with formalin) were preserved in 70% alcohol ; weak sea-water formalin should have been used, since alcohol encourages contraction and leads to damage. These factors have combined to make useless in many cases such taxonomically valuable structures as seminal vesicles, corona and fins, and to make many of my length-measurements of only relative value. Length-measurements in any case should be treated with some caution ; Russell (1932*a*, *b* ; 1933*a*, *b*) and Clarke *et al.* (1943) have shown that there is a very considerable difference in length between successive broods of *Sagitta elegans* and *S. setosa* at different times of the year, and the same may well be true of other species which have not been studied with equal thoroughness.

The hauls could not be planned much in advance, but were made when time and depth permitted. The depth of the net was calculated roughly from a visual estimation of the angle of the towing warp to the horizon, and cannot pretend to be accurate. It was my intention, at each haul, to send the net to a depth of about 1,000 m., but several hauls had to be shallower than this ; sometimes there was not time to pay out and haul in enough wire, and sometimes there was no nearby sounding on the chart and the possible existence of sea-mounts had to be borne in mind.

With the exception of the very young *Sagitta elegans* in Stations 4 and 7, every specimen has been examined for the following features :

Overall length to the nearest 0·1 mm. (excluding tail fin) measured on a glass slide graduated in half-millimetres (some of the smallest were measured by eye to 0·05 mm.).

Length of tail, expressed as percentage of total length.

Numbers of hooks, of *anterior teeth* and of *posterior teeth* ; whenever the two sides differed the larger number was taken, and I have included the smallest visible hook-rudiments.

State of development of gonads. Several not dissimilar schemes exist for classifying the developmental stages of chaetognaths, notably those of Kramp (1917, 1939), Russell (1932), Thomson (1947), Faure (1953) and David (1955). The arbitrary division into stages of a continuous process is bound to be to some extent subjective so it is desirable for each author to define the stages which he uses. I have recorded the state of development of my specimens in six stages, as follows :

Stage O : neither testes nor ovaries visible under × 100 magnification.
,, I : testes visible, but no sperm-balls or spermatozoa free in tail coelom ; ovaries visible but very small.
,, II : tail filled with spermatozoa, ovaries developing but eggs small.
,, III : tail empty, ovaries further developed, with some eggs larger than others ; some eggs may even be full-sized.
,, IV : tail empty ; all eggs full-sized ; in some cases, probably because of damage, many eggs are free in the trunk coelom.
,, V : spent, the ovaries being reduced to crumpled remnants.

Stage V seems to be almost confined to the genus *Eukrohnia.* This seems to imply that most, if not all, species of *Sagitta* die very soon after ovulation (or after the last ovulation in species such as *S. enflata* which are believed to go through more than one reproductive cycle in a lifetime). Indeed, van Oye (1931) states that this is so.

The relative duration of the several stages, the speed of transition from one stage to the next, and the relative speed of development of testes and ovaries, vary not only between one species and another, but also to some extent between individuals of one species. I have occasionally found it convenient (especially in the case of *Sagitta lyra*, see below) to record two intermediate stages.

Stages I–II : testes still retaining their shape, but some sperm-balls already free in tail coelom.
" II–III : some spermatozoa still in tail, but ovaries quite as mature as in some specimens of stage III.

DEEP-WATER HAULS

Thirteen plankton hauls were made in deep water with 2-metre nets, 12 with the stramin net and one (Station 14) with a silk net of quarter-inch mesh. The latter net, as might be expected, caught very few chaetognaths, and one of the stramin net hauls (Station 41) was spoilt by containing a large shark. The details of the samples from these stramin net hauls are shown in Table I.

Station 8 was in near-Arctic waters south-west of Greenland, Station 13 was in temperate waters between the Gulf Stream and the continental shelf off the eastern United States, and the remainder were in tropical waters ; Stations 15–33 were in the Caribbean Sea, and Stations 42–46 in the central Atlantic. Station 8 took place at night ; all the others were in daylight.

The sample from Station 8 can be compared with the catches from the *Godthaab* Expedition of 1928, described by Kramp (1939). In deep water south-west of Cape Farewell Kramp found that *Sagitta maxima* and *Eukrohnia hamata* were abundant, with " *S. planctonis* " (= *S. zetesios*) (see David, 1956) and *E. fowleri* less common. In *Rosaura* Station 8 the same four species occurred in the same order of abundance, but to them can now be added the red, deep-water species, *S. macrocephala*. It is surprising that Kramp found none of the latter species. for the *Godthaab's* hauls were made at all depths down to 2,000 m., a good deal deeper than mine which I estimated to reach 1,300 m.

A submarine ridge joins southern Greenland to southern Baffin Land about 65° N. According to Kramp neither " *Sagitta planctonis* " (= *S. zetesios*) nor *Eukrohnia fowleri* is found north of the ridge. *S. maxima* and *E. hamata*, however, both extend northwards as far as Ellesmere Land and North Greenland, and in these northern waters they are joined by *S. elegans arctica* as an offshore species. Further south in the Davis Straits the latter species is confined to inshore waters ; I found no *S. elegans* in Station 8, but did catch some very young juveniles (Stage O) in Stations 4 and 7 near the Greenland coast.

Station 13 was taken about 60 miles north-east of Cape Hatteras, and was thus only just outside the area covered by Pierce (1953). To judge by the surface temperature (17·8° C.) and the fact that the ship was being set to the southward, Station 13 must have been in the " slope " water between the Gulf Stream and the continental shelf, and the position would correspond roughly to Pierce's " Outer Shelf Zone ". Pierce recorded 11 species from this zone, and I identified eight species from the sample in Station 13, but only three species are common to the two lists, namely *Sagitta enflata*, *S. lyra* and *S. bipunctata*, as is shown on p. 225.

The five species in the *Rosaura* sample which were missing from Pierce's list all inhabit moderately deep or deep water ; few of Pierce's samples came from deeper than 200 m. Of the eight species in Pierce's list which were not found in Station 13, seven are small species which would not be caught in large numbers by a stramin net (though most of them did appear from time to time in other *Rosaura* samples). The remaining one, *S. hexaptera*, is a large species which throughout the Caribbean and the central Atlantic was one of the most regularly occurring in the *Rosaura* samples, and was often the most numerous. Pierce records it as " rare " in the Cape

Species	Pierce (1953) Outer Shelf Zone (+++, common ++, occasional +, rare)	*Rosaura* Station 13 (Numbers in sample)
Sagitta minima	+++	..
S. serratodentata	+++	..
S. helenae	+++	..
S. tenuis	++	..
S. hexaptera	+	..
Krohnitta pacifica	+++	..
K. subtilis	+	..
Pterosagitta draco	+++	..
Sagitta enflata	+++	14
S. lyra	+	2
S. bipunctata	+++	1
S. maxima	..	12
S. zetesios	..	5
S. macrocephala	..	4
Eukrohnia hamata	..	51
E. fowleri	..	14

Hatteras-Cape Fear region, and it has been occasionally recorded from as far north as Nova Scotia (Pierce quotes Huntsman, 1919); its absence from *Rosaura* Station 13 may indicate that it is common only to the southward of Cape Hatteras.

At Station 8 the surface temperature was 4·8° C., and at Station 13, 17·8° C. All the other offshore hauls with the stramin net were made in tropical waters with the surface temperatures ranging from 25·5 to 28·3° C., and throughout the extensive area from Central America to the eastern central Atlantic the catches on the whole resembled one another closely.

Of the species large enough not to be able to escape through a stramin net, *Sagitta hexaptera, S. enflata, S. maxima, S. lyra* and *S. zetesios* occurred regularly in all or nearly all of the samples, and of these *S. hexaptera* was usually the most abundant. *S. maxima*, though usually present, seems to have been distinctly scarcer in tropical waters than in the Davis Straits (Station 8).

Another sizeable species, *S. planctonis*, was found only in the samples from the two easternmost stations (45 and 46) between St. Paul's Rocks and the west coast of Africa, as was the smaller and more slender *S. friderici*. *Eukrohnia hamata*, which dominated the catches in the two most northerly stations (8 and 13), was scarce in the tropics, providing only 14 specimens in three out of nine hauls.

Of the smaller species, *Sagitta decipiens* and *Pterosagitta draco* occurred with surprising regularity and must have been abundant everywhere. The paucity of the other species does not necessarily indicate that they were rare; a stramin net would let most of them through, and my sampling technique was not adequate for such as were caught.

A special mention may be made of the two red species, *Sagitta macrocephala* and *Eukrohnia fowleri*. Of the nine tropical hauls, the estimated depth of the net was at least 1,000 m. in five of them, but not more than 900 m. in the other

TABLE I.—*Samples from Deep-water Hauls*

2-metre stramin net (except Station 14, 2 m. ½-in. net)

Station No.	Date	Lat.	Long.	Position	Depth of sea (by chart) (m.)	Surface temp. (°C.)	Approx. depth of net (m.)	*Sagitta friderici*	*S. bipunctata*	*S. robusta*	*S. serratodentata*	*S. lyra*	*S. maxima*	*S. hexaptera*	*S. decipiens*	*S. enflata*	*S. planctonis*	*S. zetesios*	*S. neglecta*	*S. pulchra*	*S. macrocephala*	*Pterosagitta draco*	*Krohnitta subtilis*	*Eukrohnia hamata*	*E. fowleri*	Total	Number of species
8	11.ix.37	58° 48′ N.,	46° 11′ W.	Off SW. Greenland	>2,750	4·8	1,300	—	—	—	—	—	85	—	—	—	—	15	—	—	19	—	—	139	6	264	5
13	10.x.37	36° 88′ N.,	74° 23′ W.	Off U.S.A. ? "Slope" water	>1,800	17·8	750	—	1	—	—	2	12	—	—	14	—	5	—	—	4	—	—	51	14	103	8
14	13.x.37	24° 53′ N.,	77° 40′ W.	Tongue of the Ocean (Bahamas)	c. 1,800	27·8	900	—	—	—	—	—	—	2	—	1	—	—	—	—	2	—	—	—	2	7	4
15	17.x.37	18° 21′ N.,	75° 25′ W.	Bet. Cuba and Jamaica	c. 1,800	28·3	1,250	—	—	2	—	11	—	43	3	16	—	—	1	—	—	4	2	1	7	90	10
27	8.xi.37	16° 22′ N.,	86° 40′ W.	West of Roatan Is., Hond.	?	?	600	—	—	7	—	19	7	51	13	33	—	9	3	—	—	1	4	—	—	147	10
28	12.xi.37	16° 44′ N.,	85° 42′ W.	N. of Bonacca Is. (Hond.)	c. 3,000	27·8	1,100	—	—	—	—	25	7	9	8	11	—	7	1	—	39	—	2	—	84	193	10
32	17.xi.37	12° 42′ N.,	80° 25′ W.	400 km. NNW. of Colon	c. 2,000	27·8	900	—	—	—	2	21	19	63	1	6	—	12	—	—	—	3	—	—	—	127	8
33	22.xi.37	11° 00′ N.,	75° 43′ W.	Off Puerto Colombia	c. 1,500	27·8	1,200	—	—	—	—	8	11	13	2	9	—	5	—	—	7	2	1	—	53	111	10
*41	18.xii.37	0° 38′ S.,	43° 42′ W.	Off. N. Brazil	2,050	26·1	900	—	—	—	—	1	—	—	—	9	—	1	—	—	—	—	—	—	—	11	3
42	21.xii.37	5° 51′ S.,	34° 38′ W.	Off NE. Brazil	2,594	26·5	1,200	—	1	—	—	4	5	44	1	4	—	4	—	2	24	1	—	7	34	131	12
43	27.xii.37	3° 35′ S.,	32° 20′ W.	19 km. N. of F. Noronha	c. 2,000	25·5	750	—	1	—	—	8	6	25	—	—	—	11	—	—	—	13	—	—	—	64	6
45	29.xii.37	4° 15′ N.,	26° 20′ W.	Equatorial current	c. 4,500	26·6	900	1	2	—	1	3	3	27	—	3	5	—	—	—	—	1	—	—	2	48	10
46	30.xii.37	7° 27′ N.,	23° 08′ W.	? Guinea current	c. 4,400	26·6	1,000	1	—	5	2	8	12	13	1	24	7	15	1	—	12	14	2	6	75	168	16
							Total	2	5	14	5	110	167	290	29	130	12	84	6	2	107	39	11	204	277	1,464	18
							Number of stations	2	4	3	3	11	10	10	7	11	2	10	4	1	7	8	5	5	9	13	—

* Catch spoilt through capture of 7-ft. shark.

TABLE II. *Samples from Inshore Hauls*

Small silk townet (about 60 meshes to 1 in.)

Station No.	Date	Lat.	Long.	Position	Depth of sea (m.)	Surface temp. (°C.)	Salinity (°/°°)	Depth of net (m.)	*Sagitta tenuis*	*S. bipunctata*	*S. elegans*	*S. serratodentata*	*S. hexaptera*	*S. enflata*	*S. neglecta*	*Pterosagitta draco*	Total
4	3.ix.37	60° 35′ N.,	46° 45′ W.	Off Julianehaab, Grnld.	550	c. 5	—	20	—	—	34	—	—	—	—	—	34
7	9.ix.37	60° 17′ N.,	44° 37′ W.	Tasermiut Fjord, Grnld	35	c. 5	—	10	—	—	8	—	—	—	—	—	8
23	30.x.37	17° 29′ N.,	88° 10′ W.	Belize Hbr., Brit. Honduras	5	28·5	—	2–3	—	—	—	—	—	6	1	—	7
38A	8.xii.37	8° 15′ N.,	59° 45′ W.	Morowhana, Brit. Guiana	12	26	10·90	2	104	—	—	—	—	—	—	—	104
40	13.xii.37	6° 40′ N.,	58° 10′ W.	Georgetown, Brit. Guiana	7	26	13·9	2	73	—	—	—	—	—	—	—	78
44	28.xii.37	0° 56′ N.,	c. 29° W.	St. Paul's Rocks	10	26	—	2	—	1	—	90	9	5	—	6	111
								Total	177	1	42	90	9	11	1	6	337

four. *S. macrocephala* occurred in none of the latter, but provided 82 specimens in four of the deeper hauls; *E. fowleri* was represented by two specimens in one (900 m.) of the less deep hauls, but by 253 in all five of the deeper ones. This fairly sharp division between 900 m. and 1,000 m. may show that my estimates of net-depth are at any rate reasonably self-consistent.

INSHORE HAULS

Six short hauls were made near the surface with a small silk townet of about 60 meshes to the inch. The details of the samples from these are shown in Table II.

The first two of these hauls (Stations 4 and 7) were taken in Greenland coastal waters. The first was, it is true, over fairly deep water (550 m.), but the coast was less than 10 miles away, and the catch looked like inshore plankton, being dominated by medusae and ophioplutei. At Station 7 there were few plutei, but again medusae were conspicuous. The only chaetognaths in these catches were some very young (stage O) *Sagitta elegans*, presumably the subspecies *arctica*; since this species did not appear in the offshore sample at Station 8, these observations tend to confirm Kramp's (1939) statement that in the Davis Straits *S. elegans* is confined to coastal waters.

The catch at Station 23 in Belize Harbour (British Honduras) calls for little comment. It was made over shallow water in bright sunshine, and the few chaetognaths caught (one *S. neglecta* and six *S. enflata*) were all very young; the largest of the *S. enflata* was only 3·1 mm. long, and the others were post-larvae still with relatively very large ventral ganglia. The rest of the catch was typical of inshore waters, and was dominated by medusae, post-larval polychaetes, and the larvae of decapods and molluscs.

The next two hauls (Stations 38A and 40) are of considerable interest. They were both taken in the complex system of rivers and creeks in British Guiana where the water is very opaque (more so than the most turbid water in the Tamar Estuary, for example), the salinity low (10·9 and 13·9‰), and the plankton abundant, varied, and entirely marine in character. The most numerous groups in the plankton were young fish and fish larvae, penaeid prawns, copepods and chaetognaths, all of the last group being *Sagitta tenuis*. These tidal waterways are discussed at greater length by Colman & Cooper (1954), and *S. tenuis* will be considered below in the section devoted to the individual species.

The last silk net haul to contain any chaetognaths, Station 44, was made a few feet off St. Paul's Rocks, the tiny, isolated land-mass in the middle of the " waist " of the Atlantic. The shelf from which the rocks project is only a few hundred metres across and it supports a generous growth of algae, hydroids, polyzoa, sponges etc., accompanied by other invertebrates. At the time of the *Rosaura*'s visit the equatorial current was sweeping between the rocks from east to west at about 2 knots, but the plankton seemed to contain a local concentration of neritic forms, including mysids, orange, blue and variegated copepods, and post-larval gastropods. The five species of chaetognath, however, were all widely-distributed oceanic species; in the sample of 111 there were a single *Sagitta bipunctata*, several each of *S. hexaptera*, *S. enflata* and *Pterosagitta draco*, and 90 *S. serratodentata*.

This population is not unlike that in the surface waters at Fernando de Noronha, some 300 miles (500 kilometres) south-west of St. Pauls' Rocks. At Fernando de Noronha in 1954 (Hosoe, 1956) *Sagitta serratodentata atlantica* made up two-thirds of the chaetognaths, and was followed in order of abundance by *S. enflata*, *Pterosagitta draco*, *Krohnitta pacifica* and *Sagitta hexaptera*.

NOTES ON THE SEVERAL SPECIES

The reference under each species heading are to good descriptions which I have found useful in identification ; they are not lists of synonymies. The latter will be found in Ritter-Záhony, 1911 ; Michael, 1911, 1919 ; Johnston & Taylor, 1921 ; Burfield & Harvey, 1926 ; Burfield, 1930, 1950 ; Kramp, 1939 ; Tokioka, 1939, 1940*a*, 1940*b* ; Thomson, 1947 ; Pierce, 1951 ; Vannucci & Hosoe, 1952 ; David, 1955, 1956, 1958 ; Furnestin, 1957.

Whenever a species has been sufficiently numerous, I have shown the details of head armature etc. separately for young forms (stages O and I) and adults (stages II and up). This seems to me to be preferable to the more usual method of showing the range of variation within different size-groups (see, for example, Thomson, 1947), since the development of head armature is more a function of maturity than of size. Furthermore, I have shown, in addition to the range of variation, the numerical distribution within the range ; this method can show up specific and racial differences better than can the range of variation alone. At the end of the paper I have summarized the head armatures and tail lengths of the adults of the species in the *Rosaura* collection.

Sagitta friderici Ritter-Záhony

Ritter-Záhony, 1911 : 19.
Fraser, 1952 : 14.
Vannucci & Hosoe, 1952 : 14.
Faure, 1953 : 26.
Furnestin, 1954 ; 1957 : 113.

Mme. Furnestin (Faure, 1953 and Furnestin, 1954) has shown that *S. friderici* is distinguishable from *S. bipunctata*, but there has been some question as to whether *S. friderici* is separable from *S. tenuis* ; the latter point will be discussed in the section below on *S. tenuis*. Only two specimens of *S. friderici* occurred in the *Rosaura* collection, one from each of Stations 45 and 46. Both these were over deep water in the eastern central Atlantic, and bear out the suggestion of Vannucci & Hosoe (1952) that this species is not so neritic as was suggested by Faure (1953).

Length (mm.)	Tail (% length)	Hooks	Ant. teeth	Post. teeth	Stage
12·7	26	8	8	18	II
6·8	25	7	6	12	I

The best character by which this species can be separated from *S. bipunctata* seems to be the propinquity of the seminal vesicle to the posterior fin ; in *S. bipunctata* there is a gap, but in *S. friderici* there is not.

Sagitta tenuis Conant

Michael, 1911 : 72.
Pierce, 1951 : 219.
Tokioka, 1955 : 57.

This is not yet a well-known species, and several authors have cast doubt on its validity ; the only sound work on its distribution has been that of Pierce (1951, 1953, 1958) and of Bieri (1957).

Conant (1896) described *S. tenuis* rather inadequately from specimens taken in Kingston Harbour, Jamaica. Ritter-Záhony at first (1910*b*) regarded it as a synonym for *S. bipunctata*, but later (1911) listed it among a number of doubtful species. Michael (1911) re-examined Conant's material and kept *S. tenuis* separate from *S. bipunctata*. Pierce (1951) redescribed *S. tenuis*, but tentatively regarded it as a synonym for *S. friderici* on the grounds of its resemblance to Ritter-Záhony's (1911) description of the latter. Fraser (1952), however, in his valuable discussion of the confusion between *S. bipunctata* and other species, feels that *S. tenuis* should be kept separate from *S. friderici* if only because of the great difference in size between the two : *S. tenuis* less than 8 mm., mature *S. friderici* more than 10 mm. Tokioka (1955), after expression some preliminary doubt, comes to the conclusion that *S. tenuis* and *S. friderici* are both valid species, while Bieri (1957) suggests that, in the coastal waters of Peru and Lower California at any rate, the two species represent the ends of an unbroken sequence of ecotypic variation. Finally, Furnestin (1957) firmly separates the two, placing them both, together with *S. setosa* Müller, *S. hispida* Conant and *S. helenae* R.–Z., in her " groupe *friderici* " of neritic species.

After examining 103 specimens from Station 38A and 73 from Station 40 (both from tidal rivers in British Guiana) I am in no doubt that my material is identical with Pierce's *S. tenuis*, and that *S. tenuis* is a valid species separate from *S. friderici*.

From Station 38A there were 103 specimens, including 7 stage I, 48 stage II and 48 stage III ; in the 73 specimens from Station 40 there were no stage I, 22 stage II and 51 stage III. In the accompanying tables I have omitted those of stage I, because they had not yet acquired their full complement of teeth ; the two lots are shown separately because there are certain small differences between them, viz.

(1) *Front teeth :* most of those from Station 38A have 5, most of those from Station 40 have 6.

(2) *Anterior fins :* these begin somewhat further forward in station 38A than in Station 40, and are somewhat longer ; they end at about the same level in both lots.

In a separate table I also show the anatomical details of six *S. tenuis* kindly sent to me by Dr. Pierce, collected by him at Cedar Keys, Florida. As regards length, numbers of back teeth and front teeth, position of hind-end of anterior fins, and length of posterior fins, there is no difference between those from Florida and those from British Guiana. On the other hand the Floridan specimens have somewhat shorter tails (26–29% *v.* 27–33%), fewer hooks (7, 8 *v.* 8, 9), shorter anterior fins (16–21% *v.* 18–26%) which also begin further back (34–38% *v.* 29–36%), and less of the posterior fin on the tail (52–65% *v.* 58–75%). These differences do not seem more significant, however, than those already noticed between the two lots from British

Sagitta tenuis

Length

mm.	38A	40	Total
>7	1	—	**1**
6·5–7	1	—	**1**
6–6·5	3	2	**5**
5·5–6	10	6	**16**
5–5·5	18	14	**32**
4·5–5	27	36	**63**
4–4·5	25	14	**39**
3·5–4	11	1	**12**

Tail

% lgth.	38A	40	Total
<27	5	1	**6**
27	9	1	**10**
28	10	7	**17**
29	13	14	**27**
30	21	7	**28**
31	19	14	**33**
32	10	18	**28**
33	4	9	**13**
34	4	1	**5**
>34	1	1	**2**

	Hooks			Anterior teeth			Posterior teeth		
No.	38A	40	Total	38A	40	Total	38A	40	Total
3	—	—	—	—	—	—	—	—	—
4	—	—	—	10	—	**10**	—	—	—
5	—	—	—	69	13	**82**	—	—	—
6	—	—	—	14	40	**54**	2	—	**2**
7	1	—	**1**	—	17	**17**	3	—	**3**
8	55	44	**99**	—	1	**1**	6	1	**7**
9	38	28	**66**	—	—	—	6	3	**9**
10	—	—	—	—	—	—	14	10	**24**
11	—	—	—	—	—	—	18	12	**30**
12	—	—	—	—	—	—	20	20	**40**
13	—	—	—	—	—	—	13	12	**25**
14	—	—	—	—	—	—	17	7	**24**
15	—	—	—	—	—	—	1	6	**7**
16	—	—	—	—	—	—	4	1	**5**

Anterior fins

Anterior end

% lgth.	38A	40	Total
28	4	—	**4**
29	8	1	**9**
30	10	2	**12**
31	11	6	**17**
32	23	16	**39**
33	18	15	**33**
34	6	17	**23**
35	6	9	**15**
36	2	5	**7**
37	1	2	**3**
38	2	—	**2**
39	2	—	**2**

Posterior end

% lgth.	38A	40	Total
49	1	2	**3**
50	4	1	**5**
51	5	5	**10**
52	18	13	**31**
53	7	15	**22**
54	18	14	**32**
55	8	10	**18**
56	18	7	**25**
57	5	4	**9**
58	3	2	**5**
59	1	—	**1**
60	2	—	**2**
>60	3	—	**3**

Length of fin

% lgth.	38A	40	Total
16	—	1	**1**
17	—	4	**4**
18	4	4	**8**
19	12	13	**25**
20	9	19	**28**
21	10	16	**26**
22	19	6	**25**
23	14	6	**20**
24	7	3	**10**
25	8	—	**8**
26	7	1	**8**
27	1	—	**1**
28	2	—	**2**

Gap between fins

% lgth.	38A	40	Total
3	1	—	**1**
4	7	9	**16**
5	22	10	**32**
6	12	16	**28**
7	15	15	**30**
8	13	11	**24**
9	12	5	**17**
10	8	5	**13**
11	3	1	**4**
12	—	—	—
13	—	1	**1**

Posterior fins

Anterior end

% lgth.	38A	40	Total
56	—	1	**1**
57	9	6	**15**
58	4	8	**12**
59	8	10	**18**
60	19	17	**36**
61	15	10	**25**
62	15	10	**25**
63	7	4	**11**
64	7	2	**9**
65	7	2	**9**
66	2	3	**5**
67	—	—	—
68	1	—	**1**
69	1	—	**1**

Posterior end

% lgth.	38A	40	Total
84	2	1	**3**
85	5	3	**8**
86	7	13	**20**
87	19	21	**40**
88	32	23	**55**
89	12	9	**21**
90	13	2	**15**
91	3	1	**4**
92	1	—	**1**
93	1	—	**1**

Length of fin

% lgth.	38A	40	Total
21	1	—	**1**
22	3	1	**4**
23	3	4	**7**
24	5	2	**7**
25	11	6	**17**
26	15	12	**27**
27	25	20	**45**
28	12	13	**25**
29	10	9	**19**
30	8	5	**13**
31	1	1	**2**
32	1	—	**1**

Percentage of fin on tail

% lgth.	38A	40	Total
<58	5	2	**7**
58–59	4	3	**7**
60–61	5	2	**7**
62–63	12	8	**20**
64–65	12	11	**23**
66–67	20	14	**34**
68–69	13	15	**28**
70–71	12	8	**20**
72–73	3	3	**6**
74–75	3	3	**6**
76–77	2	2	**4**
>77	4	2	**6**

Six Sagitta tenuis *from Cedar Keys, Florida (Collected by Dr. Pierce,* 15.*iv*.49)

Length (mm.)	Tail (% lgth.)	Hooks No.	Ant. teeth No.	Post. teeth No.	Stage	Ant. fin. (% lgth.)	Ant. fin. (% lgth.)	Gap (% lgth.)	Post. fin. % lgth.)	Post. fin. (% lgth.)	Percentage of post. fin on tail
6·05	26	8	6	15	III	37–54	17	9	63–88	25	56
6·05	26	8	5	12	III	38–55	17	6	61–88	27	52
5·95	28	7	6	14	III	36–54	18	9	63–89	26	65
5·50	29	7	5	11	III	35–51	16	8	59–86	27	56
5·50	27	8	5	13	III	34–55	21	7	62–87	25	56
5·35	29	8	6	13	III	35–53	18	7	60–86	26	58

Guiana; in each instance there is an overlap, and there seem to be no grounds for regarding the Floridan and British Guianan specimens as belonging to different species. As mentioned above, Faure (1953) gives good reasons for keeping *S. tenuis* separate from *S. friderici*, but she also casts some doubt on the identity of Pierce's with Conant's *S. tenuis*. Pierce (1951), however, compared Conant's Jamaican syntypes directly with his own Floridan material and this, he states, " revealed that they were the same species ".

Hitherto not very much has been known about the distribution of *S. tenuis*. Pierce (1951) found it abundant on the west coast of Florida, where it flourished in a salinity of 35‰ but tended to avoid the most inshore waters where the salinity fell below about 25‰. (In the latter positions it was replaced by another small species *S. hispida* Conant.) Pierce (1953, 1958) also described its occurrence off North Carolina. Here *S. tenuis* is markedly neritic; its seaward distribution is limited by the 36‰ isohaline, and it is most abundant in such places as the southern mouth of the Pamlico Sound, where it occurs in salinities as low as, but not lower than, 22·7‰. The type locality of *S. tenuis* is Kingston Harbour, Jamaica, and other places mentioned by Pierce are various inlets and estuaries in the south-eastern United States where the salinity will be reduced, but not very reduced. Bieri (1957) records *S. tenuis* in the coastal current of Peru in salinities of 32–34‰ and temperatures of 18–20° C.

In the areas worked by Pierce and Bieri, then, *S. tenuis* seems to be confined to the salinity range 23–36‰. The *Rosaura* specimens show that in British Guiana it flourishes and breeds in salinities as low as 10‰. It would clearly be desirable to have a series of samples of *S. tenuis*, with salinity measurements, from various inlets and estuaries round the coast of Central America and from islands other than Jamaica.

Sagitta bipunctata Quoy & Gaimard

Ritter-Záhony, 1911 : 16.
Michael, 1911 : 41.
Ghirardelli, 1950 : 115.
Fraser, 1952 : 13.
Faure, 1953 : 36.
Furnestin, 1957 : 171.

S. bipunctata has often been confused with other species (see the valuable discussion on this point by Fraser (1952)), but Mme. Furnestin (Faure, 1953; Furnestin, 1954, 1957) has clearly established its identity and diagnostic limitations.

There were only six specimens in the *Rosaura* collection (it is too slender a species for the stramin net); one was from Station 13 off the eastern United States, and the others were all caught in the central Atlantic. Their specifications were as follows:

Length (mm.)	Tail (% length)	Hooks	Ant. teeth	Post. teeth	Stage
11·8	25	8	4	10	II
11·1	27	10	7	15	III
11·0	25	8	7	13	II
10·8	24	9	6	16	II
9·6	28	9	6	16	II
6·7	24	9	7	14	III

The smallest specimen had already reached stage III in maturity.

Sagitta elegans Verrill

Ritter-Záhony, 1911: 14.
Fraser, 1952: 7.
Fraser, 1957.

As mentioned earlier (p. 227) 43 young specimens were taken close to the Greenland coast. The largest was 9 mm. long, all were stage O juveniles, and none had acquired the adult number of teeth.

Sagitta robusta Doncaster

Ritter-Záhony, 1911: 16.
Michael, 1919: 259 (as *S. ferox*).
Burfield & Harvey, 1926: 100.
Tokioka, 1939: 127 (as *S. ai*).
Tokioka, 1940*a*: 4 (as *S. ai*).
Thomson, 1947: 13.

"The identity of *S. robusta* is most confused" (Thomson, 1947). This statement is true if *S. ferox* Doncaster is regarded as a species separable from *S. robusta*, a point about which there has been much argument (see below); otherwise *S. robusta* is an easily recognized species, with its unusually large head and its stiff, slim body.

Doncaster (1902), when he described both species from the Indian Ocean, himself suggested that they might prove to be identical. Ritter-Záhony (1911) united them under the name *S. robusta*. Burfield & Harvey (1926), after re-examining Doncaster's original material, concluded that on balance it was better to regard *S. ferox* as a synonym of *S. robusta*; they saw a large number of specimens.

On the other hand Fowler (1906), and after him Michael (1911), described a Far Eastern species as *S. ferox* and regarded it as separable, on the evidence of published descriptions, from *S. robusta*; according to Thomson (1947), however, the *S. ferox* of Fowler and of Michael was really the *S. robusta* of Doncaster. Tokioka (1939 and 1940*a*), working in Japanese waters, found two species which he named *S. robusta* and *S. ai*, but according to Thomson Tokioka's *robusta* is really Doncaster's *ferox*, and *ai* is Doncaster's *robusta*. Finally Thomson says that in the waters south-east of Australia " the two are easily differentiated ".

The head armatures of *S. robusta* and *S. ferox* are almost identical, but Thomson (1947) gives the following characters on which to separate the two species (all figures expressed as percentages of total length) :

	Width	Width of head	Length of ant. fin	Length of Post. fin
S. robusta	6·1–6·6	9·4–11·4	25·5–30·4	25·4–30·8
S. ferox	5·4–5·8	7·7–8·3	21·1–22·7	25·0–27·0

Tokioka (1939) stresses another character, namely that the mature seminal vesical has a large head in his *S. robusta* (= *S. ferox* Doncaster) but not in his *S. ai* (= *S. robusta* Doncaster).

Unfortunately the 14 specimens of *S. robusta* from the *Rosaura* collection seem only to confuse the issue ; some of their characters are those of Thomson's *S. robusta*, but others of his *S. ferox*.

Width. After their long stay in alcohol the *Rosaura* specimens are bilaterally concave, and no longer suitable for width-measurement.

Length. They show no obvious signs of longitudinal contraction. The largest *Rosaura* specimen (stage II) measured 11·5 mm.; this suggests *S. ferox*. (Doncaster's *ferox* reached 13 mm., but his *robusta* 16 mm., while Thomson records a *robusta* as long as 22 mm.)

Width of head. This ranged from 9·5 to 12·2% of the body length, and 10 of the 14 specimens lay within the range 10·0–11·1%. This clearly suggests *robusta*.

Length of anterior fins. The anterior fins could be measured in 12 specimens, and ranged from 17·0 to 20·0% ; this as strongly suggests *ferox*.

Seminal vesicles. Only three specimens had vesicles which seemed to be mature, but none of them had a large head. As far as it goes this suggests *robusta*.

It should be noticed that each of these features in the *Rosaura* specimens belongs definitely to one or other of Thomson's species ; they are not intergrades between the two.

The other anatomical details of the *Rosaura* specimens are as follows :

Length (mm.)	Tail (% length)	Hooks	Ant. teeth	Post. teeth	Stage
11·5	25	8	10	12	II
11·2	26	7	10	12	II
10·9	26	7	8	12	II
10·6	26	7	9	12	II
10·4	24	7	8	12	I
10·4	27	8	9	12	I
10·0	26	7	8	15	II
9·6	26	7	8	11	II
9·5	26	7	7	12	I
9·1	24	8	8	13	I
8·6	28	8	9	13	I
8·4	27	7	7	12	I
8·3	27	7	7	12	I
5·8	28	9	7	11	O

Now, those who have found it difficult or impossible to separate *S. ferox* from *S. robusta* (Doncaster, Ritter-Záhony, Burfield & Harvey, Colman) have worked on material from either the Indian or the Atlantic Ocean. The Pacific Ocean, on the other hand, has provided the material for those (Fowler, Michael, Tokioka, Thomson) who have distinguished these two species. This discrepancy could, perhaps, be explained on the supposition that *S. robusta* is a single, though somewhat variable, species in the Indian and Atlantic Oceans, but is evolving in the Pacific Ocean into two recognizable subspecies, *S. robusta robusta* and *S. robusta ferox*. Such an explanation, if true, would be surprising, since the Indian Ocean is, in general, more closely linked faunistically with the Pacific than with the Atlantic.

Sagitta serratodentata Krohn

Ritter-Záhony, 1911 : 22.
Michael, 1911 : 39.
Thomson, 1947 : 15.
Ghirardelli, 1950 : 120.
Fraser, 1952 : 8.
Fraser, 1957.
Furnestin, 1957 : 147.

S. serratodentata was for long regarded as a single variable species. Tokioka (1940*b*) recognized two forms or subspecies *S. s. atlantica* and *S. s. pacifica* in Australian waters, and Thomson (1947) added a third form *S. s. tasmanica* from the same region. Fraser (1952) states that all three varieties occur together in Scottish waters, and doubts their subspecific validity ; but later (1957) he ascribes the variety *tasmanica*, in the eastern Atlantic, to more northern waters, and *atlantica* to warmer, southern and more saline waters. Furnestin (1957) firmly divides the species into three separate ones : *S. serratodentata* (= *f. atlantica*), *S. pacifica* and *S. tasmanica*.

The main character on which this separation is made is the structure and appearance of the mature seminal vesicle. There were 31 *Rosaura* specimens with mature seminal vesicles, and these were all of the *atlantica* type ; so fortunately, whatever the final decision on these taxa may be, the *Rosaura* material will still belong to *S. serratodentata*, the type-locality of which is Messina.

There were 95 *Rosaura* specimens, of which only five were caught by the stramin net (at Station 32 in the western Caribbean, and at 45 and 46 in the eastern central Atlantic) ; the other 90 all came from one short haul with the small silk net within a few yards of St. Paul's Rocks just before noon in bright sunshine. Table II (p. 226) shows that at the time of the *Rosaura*'s visit *S. serratodentata* was by far the commonest surface-living chaetognath at St. Paul's Rocks.

The smallest specimens measured 4·4 mm. (stage O), and the largest 9·6 mm. (stage III). The size-range and frequency of occurrence of the maturity stages were as follows :

Stage	Size-range (mm.)	Number
O	4·4–6·9	5
I	5·8–8·5	30
II	6·8–9·5	41
III	7·3–9·6	18
IV	7·85	1

Other details were as follows :

Sagitta serratodentata

Length				Tail (as % of length)				Hooks				Anterior teeth			Posterior teeth			
mm.	O, I	II–IV	Total	%	O, I	II–IV	Total	No.	O, I	II–IV	Total	O, I	II–IV	Total	No.	O, I	II–IV	Total
>9	—	13	**13**	19	1	—	**1**	5	—	—	—	2	—	**2**	5–12	5	—	**5**
8–9	5	34	**39**	20	2	—	**2**	6	4	28	**32**	2	—	**2**	13	7	—	**7**
7–8	17	12	**29**	21	—	—	—	7	27	30	**57**	8	1	**9**	14	3	2	**5**
6–7	8	1	**9**	22	4	7	**11**	8	4	2	**6**	11	17	**28**	15	7	8	**15**
5–6	3	—	**3**	23	3	11	**14**	9	—	—	—	10	33	**43**	16	10	10	**20**
4–5	2	—	**2**	24	11	18	**29**	10	—	—	—	2	8	**10**	17	1	8	**9**
				25	4	21	**25**	11	—	—	—	—	—	—	18	2	10	**12**
				26	9	3	**12**	12	—	—	—	—	1	**1**	19	—	6	**6**
				27	—	—	—								20	—	6	**6**
				28	—	—	—								21	—	2	**2**
				29	1	—	**1**								22	—	7	**7**
															25	—	1	**1**

Sagitta lyra Krohn

Ritter-Záhony, 1911 : 8.
Ghirardelli, 1950 : 109.
Fraser, 1952 : 9.
David, 1955 : 256.
Furnestin, 1957 : 231.

Sagitta lyra, *S. maxima* and *S. gazellae* have, until recently, often been confused, in spite of the fact that Ritter-Záhony showed that the adults can be separated on tail-length alone :

Species	Tail (as % of length)
S. gazellae	10–14
S. lyra	14–18
S. maxima	19–25

There can be a certain amount of overlap between young *S. lyra* and old *S. maxima* and between young *S. gazellae* and old *S. lyra*, since in young stages the tail tends to be proportionately longer ; almost all the adults, however, can apparently be sorted with confidence from Ritter-Záhony's figures.

Much of the confusion has been caused by the habit of these species of shedding some of their hooks and posterior teeth on reaching maturity ; this habit is least marked in *S. maxima*, most marked as regards hooks in *S. lyra*, and as regards posterior teeth in *S. gazellae*. Formulae for head armatures are therefore of no value in these species unless the state of maturity is also given.

David (1955) has shown that *S. gazellae* is distinct from *S. lyra*, not only anatomically, but also geographically. *S. gazellae* is confined to the Antarctic and to the sub-antarctic south of the subtropical convergence, whereas *S. lyra* occupies subtropical and tropical latitudes ; the two species overlap very little, if at all.

S. maxima is the only one of these three species in arctic waters, where it is abundant, and it also extends into the tropics and (David, 1958) to the Antarctic. It occurred regularly with *S. lyra* in the *Rosaura* catches throughout the Caribbean and the central Atlantic.

Furnestin (1957) has summarized observations on *S. lyra* by herself, Ghirardelli (1950) and Hamon (1952) in the general region of the Mediterranean and the water off north-west Africa; these waters can be classified as warm-temperate to subtropical. She finds an unbroken sequence from younger forms with 6–10 hooks and 4–12 posterior teeth, through numerous intermediates with 5–9 hooks and 8–16 posterior teeth, to adults with as few as 3 hooks and 2 posterior teeth; only in the last stage are the ovaries well developed (= my stages III and IV). Mr. David (in a letter) says that in southern subtropical waters *S. lyra* behaves in much the same way, losing hooks and posterior teeth gradually with advancing maturity; in particular he mentions having seen *S. lyra* with 4 and 5 hooks.

This is in contrast to the *Rosaura* material, in which there are either 3 hooks (one has only 2), or 6 or more; in 110 specimens there is not one with either 4 or 5 hooks on either side. The difference between the two lots was so striking that at first (before seeing either Furnestin (1957) or David (1955)) I thought that there were two species, each of which identified itself as *S. lyra*. Eventually, however, it became apparent that almost all of form A (6 hooks or more) were in stage I or II, and almost all form B (3 hooks) were in stages III or IV, as shown in the tables below. (I have divided other species into stages O and I as against stages II–IV or V, but the facts about *S. lyra* are more clearly shown by dividing them into forms A and B as defined above.)

Two of the *Rosaura* specimens came from Station 13 off the eastern United States, but all the rest were from ten tropical stations.

Size-range and frequency of maturity stages. There were none of stage O, and I have included two intermediate stages, I–II and II–III. In I–II the testis was still visible as such but there were already free sperms in the tail; there were two examples, one with 8 hooks and 10 posterior teeth, the other with 3 hooks and 3 posterior teeth. In stages II–III some of the eggs had increased in size as in an ovary of early stage III, but the sperms had not been evacuated from the tail. There were seven in stages II–III; six had 3 hooks, but one had 3 hooks on one side and 6 on the other; four had from 5 to 9 back teeth, one had 3, one 2, and one had 3 teeth and 6 empty sockets whose teeth must have been very recently lost. (Incidentally, it is the posterior hooks and the lateral teeth which are lost.)

Stage	Size-range (mm.)	Number
I	13·6–26·0	6
I–II	13·5, 15·8	2
II	15·3–26·4	31
II–III	17·9–23·3	7
III	15·0–27·5	56
IV	16·9–26·7	7

Anatomical details are given below (columns A, 6 or more hooks; columns B, 3 or 2 hooks).

All but two in group B were riper than stage II, whereas none in group A was riper than stage II; this shows that in the tropical Caribbean and central Atlantic the shedding of both hooks and posterior teeth takes place (in the great majority of cases) during the evacuation of sperm from the tail, i.e., while the individual is advancing from stage II to stage III. Furthermore, five individuals with only 3

Length			Tail (% length)			Hooks			Ant. teeth		Post. teeth		Maturity		
mm.	A	B	%	A	B	No.	A	B	A	B	A	B	Stage	A	B
>27	—	1	*13*	1	3	*1*	—	—	—	—	—	1	*I*	6	—
25–27	3	11	*14*	4	7	*2*	—	1	—	—	—	35	*I–II*	1	1
23–25	6	22	*15*	10	28	*3*	—	70½	—	—	—	31	*II*	30	1
21–23	8	18	*16*	10	23	*4*	—	—	1	—	—	—	*II–III*	—	7
19–21	8	7	*17*	7	8	*5*	—	—	2	1	—	1	*III*	—	56
17–19	6	5	*18*	1	2	*6*	6	½	3	11	1	1	*IV*	—	7
15–17	5	7	*19*	1	1	*7*	20	—	13	40	3	—			
<15	1	1	*20*	3	—	*8*	8	—	16	20	7	2			
						9	3	—	2	—	10	1			
						10	—	—	—	—	14	—			
						11	—	—	—	—	2	—			

hooks still had five or more posterior teeth, whereas none in group A had fewer than 6 ; this shows that the hooks tend to be shed slightly in advance of the posterior teeth. The change-over is very abrupt in these tropical specimens, and not gradual (see above) as in subtropical waters.

Apart from the length of the tail, the claw-like hooks of fully mature *S. lyra* (Ritter-Záhony, 1911, fig. 8 ; Ghirardelli, 1950, fig. 2b ; David, 1955, fig. 5c ; Furnestin, 1957, phot. 45 and 47, fig. 93) serve at once to distinguish this species from *S. maxima*. David (1955) and Fraser (1957) describe a further difference ; in *S. maxima* the lateral nerve runs below the posterior fin, whereas in *S. lyra* the nerve splits and passes on each side of the fin.

Sagitta maxima (Conant)

Ritter-Záhony, 1910 : 264 ; 1911 : 8.
Fraser, 1952 : 8.

S. maxima greatly resembles *S. lyra* in size, transparency and flaccidity, but the former's tail is relatively longer and, as mentioned above, *S. maxima* never develops the claw-shaped hooks so characteristic of mature *S. lyra*.

Of the 167 specimens, 85 came from Station 8 off Greenland ; the rest were distributed fairly evenly through the remaining samples.

S. maxima is one of the few species in the *Rosaura* collection to show signs of geographic variation, as can be seen from the tables below. As regards tail-length and number of anterior teeth there is agreement throughout the range covered, but in length, number of hooks and number of posterior teeth, the Greenland specimens are distinct from the tropical ones ; those from Station 13 off the eastern United States are intermediate, but incline more towards the Greenland forms. (Station 13 produced 7 stage O and 5 stage I, but unfortunately no adults.)

Length. The 42 adults (stages II–IV) from Station 8 ranged in size from 42 to 59 mm., whereas those from Stations 27–46 ranged from 16·2 to 34·6 mm., leaving a gap between the two series of 7·4 mm. Admittedly, those from Station 8 were well preserved, whereas the others were all more or less contracted, but even so I do not think that the latter could ever have been nearly so large as the former.

Among the younger specimens, all-stage I from Station 8 were larger than those from any other stations, most of them being as big as the adults. The O's and I's from Station 13, while smaller than those from Station 8, are larger than those from the tropics and provide a link between the two.

Hooks. The adults of Station 8 all possessed 6, 7 or 8 hooks, whereas those from the tropics had 3, 4 or 5, with only one 6 and one 7.

The younger specimens present a less clear picture, because of their greater range in hook-number and because their numbers are few.

Posterior teeth. The adults from Station 8 have more posterior teeth than do those from the tropics, the majority having 5–8 as compared with 3–5. Again the greater range in the young stages obscures the picture.

In the following tables, adults (II–IV) are shown in heavy type. Station 8, Station 13 and Stations 27–46 are shown separately.

Sagitta maxima

Length	St. 8		St. 13		Sts. 27–46	
mm.	O, I	II–IV	O, I	II–IV	O, I	II–IV
56–60	—	**5**	—	—	—	—
52–56	2	**11**	—	—	—	—
48–52	7	**11**	—	—	—	—
44–48	12	**10**	—	—	—	—
40–44	8	**5**	—	—	—	—
36–40	1	—	—	—	—	—
32–36	2	—	—	—	—	**3**
28–32	1	—	3	—	—	**12**
24–28	5	—	6	—	—	**20**
20–24	1	—	3	—	2	**17**
16–20	2	—	—	—	3	**6**
12–16	1	—	—	—	5	—
8–12	1	—	—	—	2	—

Tail (as % of length)	St. 8		St. 13		Sts. 27–46	
%	O, I	II–IV	O, I	II–IV	O, I	II–IV
16	1	—	—	—	—	**1**
17	—	—	—	—	2	**1**
18	—	—	—	—	2	—
19	—	**1**	—	—	—	**2**
20	2	**3**	—	—	—	**1**
21	3	**9**	1	—	2	**6**
22	7	**11**	—	—	—	**6**
23	8	**7**	1	—	2	**7**
24	13	**6**	5	—	—	**7**
25	3	**2**	2	—	—	**8**
26	1	**2**	1	—	—	**5**
27	2	**1**	1	—	2	**9**
28	2	—	1	—	—	**2**
29	—	—	—	—	—	**1**
30	—	—	—	—	1	**1**
31	1	—	—	—	1	—

	Hooks						Anterior teeth						Posterior teeth					
	St. 8		St. 13		Sts. 27–46		St. 8		St. 13		Sts. 27–46		St. 8		St. 13		Sts. 27–46	
No.	O, I	II–IV	O, I	II–IV	O, I	II–IV	O, I	II–IV	O, I	II–IV	O, I	II–IV	O, I	II–IV	O, I	II–IV	O, I	II–IV
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	—	—	5	**5**	—	—	—	**6**	2	—	—	—	—	**4**
3	—	—	—	—	—	**8**	16	**12**	1	—	3	**41**	3	—	—	—	—	**21**
4	—	—	—	—	1	**38**	14	**22**	9	—	4	**11**	7	**2**	2	—	2	**28**
5	2	—	—	—	1	**15**	5	**8**	2	—	1	**8**	7	**9**	4	—	3	**10**
6	4	**8**	—	—	4	**1**	2	—	—	—	4	—	15	**18**	5	—	2	—
7	17	**24**	1	—	1	**1**	1	—	—	—	—	—	7	**7**	1	—	1	—
8	7	**10**	9	—	1	—	—	—	—	—	—	—	2	**5**	—	—	1	—
9	5	—	2	—	2	—	—	—	—	—	—	—	—	**1**	—	—	2	—
10	8	—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	1	—

Sagitta hexaptera d'Orbigny

Fowler, 1906 : 11.
Ritter-Záhony, 1911 : 7.
Michael, 1911 : 30 ; 1919 : 245.
Burfield & Harvey, 1926 : 95.
Burfield, 1930 : 210.
Thomson, 1947 : 10.
Fraser, 1952 : 9.
Vanucci & Hosoe, 1952 : 15.
Furnestin, 1957 : 201.

This large, transparent species was not found in the samples from Stations 8 and 13, but occurred regularly throughout the Caribbean and the central Atlantic. The specimens were quite well preserved (except for the fins) and were not contracted. The bodily proportions and head armature were very consistent throughout, and showed no sign of division into geographical races. The anterior teeth, which are long, thin, and project forwards in a very characteristic manner, afford the best diagnostic feature (see Furnestin (1957), fig. 81).

Of the 299 specimens, the smallest measured 6·6 mm. (stage O); the largest, though only in stage I, measured 38·7 mm.

The size-range and frequency of occurrence of the maturity stages were as follows:

Sagitta hexaptera

Stage	Size-range (mm.)	Number
O	6·6–28·2	35
I	11·4–38·7	133
II	14·0–36·6	112
III	15·7–28·5	15
IV	18·2–34·1	4

Other anatomical details were as follows:

Length				Tail (% length)				Hooks				Anterior teeth			Posterior teeth		
mm.	O, I	II–IV	Total	%	O, I	II–IV	Total	No.	O, I	II–IV	Total	O, I	II–IV	Total	O, I	II–IV	Total
36–40	1	1	**2**	*15*	1	—	**1**	*0*	—	—	—	—	—	—	—	5	**5**
32–36	1	7	**8**	*16*	—	2	**2**	*1*	—	—	—	—	—	—	5	32	**37**
28–32	13	4	**17**	*17*	5	3	**8**	*2*	—	—	—	13	16	**29**	49	60	**109**
24–28	19	28	**47**	*18*	7	7	**14**	*3*	—	—	—	107	87	**194**	41	20	**61**
20–24	38	57	**95**	*19*	9	16	**25**	*4*	—	—	—	44	28	**72**	27	10	**37**
16–20	48	32	**80**	*20*	31	46	**77**	*5*	1	4	**5**	3	—	**3**	36	3	**39**
12–16	36	2	**38**	*21*	33	25	**58**	*6*	2	10	**12**	—	—	—	8	1	**9**
8–12	9	—	**9**	*22*	37	18	**55**	*7*	67	44	**111**						
<8	3	—	**3**	*23*	21	8	**29**	*8*	32	53	**85**						
				24	12	4	**16**	*9*	41	17	**58**						
				25	10	1	**11**	*10*	23	3	**26**						
				26	1	—	**1**	*11*	2	—	**2**						
				27	1	—	**1**										

The *Rosaura S. hexaptera* were of additional interest in that some of them contained two-tailed cercarias which varied in body-length from 0·35 mm. to 1·2 mm. Out of 299 *S. hexaptera* 13 contained cercarias; one was in the gut, but all the others were lying free in the body cavity. They came from Stations 15, 27, 32 and 33, all in the Caribbean Sea. Dr. Dawes has been kind enough to examine them, and has identified them (Dawes, 1958) as *Cercaria owreae* Hutton (1954). No similar parasites were seen in any other species, though some (e.g. *S. enflata* and *S. maxima*) were quite as transparent as *S. hexaptera*, in which the cercarias were conspicuous.

In the sample from Station 45, one *S. hexaptera* contained many small multinucleate parasites in the body cavity, which Dr. Dawes thinks are not helminths.

Sagitta decipiens Fowler

Ritter-Záhony, 1911 : 27.
Michael, 1919 : 254.
Thomson, 1947 : 20.

The 29 specimens of this somewhat slender species came from seven stations in the Caribbean and central Atlantic. Twenty-one were from two stations, 27 and 28, in the Gulf of Honduras; this may indicate that this species is commoner at the western extremities of the Caribbean Sea than it is elsewhere.

The specimens ranged in size from 6·3 to 13·5 mm. (both were at stage II). The size-range and frequency of occurrence of the maturity stages were as follows:

Stage	Size-range (mm.)	Number
O	7·6	1
I	8·8–11·1	6
II	6·3–13·5	22
III	—	0
IV	10·8	1

Other specifications were as follows:

Length (mm.)		Tail (% length)		Hooks		Ant. teeth		Post. teeth	
mm.	Total	%.	Total	No.	Total	No.	Total	No.	Total
12–14	**8**	*20*	**2**	*6*	**18**	*4*	**1**	*10*	**1**
10–12	**17**	*21*	**10**	*7*	**11**	*5*	**0**	—	—
8–10	**2**	*22*	**7**			*6*	**13**	*13*	**3**
6–8	**2**	*23*	**5**			*7*	**9**	*14*	**4**
		24–29	**5**			*8*	**6**	*15*	**6**
								16	**12**
								17	**1**
								20	**2**

Sagitta enflata Grassi David, 1956

Fowler, 1906: 8.
Ritter-Záhony, 1911: 13.
Michael, 1911: 28; 1919: 242.
Burfield & Harvey, 1926: 95.
Thomson, 1947: 11.
Vannucci & Hosoe, 1952: 10.
Furnestin, 1957: 213.

This medium-sized, transparent species occurred throughout the Caribbean and the central Atlantic, and also in Station 13 off the eastern United States (it was not found in Station 8 off Greenland). A few very young ones (the largest measuring only 3·1 mm.) were caught by the small silk townet in the harbour at Belize, British Honduras (Station 23). This agrees with previous records that *S. enflata* is one of the few oceanic species that penetrate inshore waters; on the Queensland coast, for example, it is the commonest species in the neritic waters between the Great Barrier Reef and the mainland (Burfield, 1950).

In one character, the number of anterior teeth, there is a difference between those from the temperate Station 13 and those from the tropical stations. Of the 14 specimens from Station 13, six had 5 anterior teeth, seven had 6 and one had 8; in the Caribbean and central Atlantic the great majority had 8 or 9, with a considerable number of 7's and 10's.

Of the 135 *S. enflata*, the smallest (excluding the very young ones mentioned above from Station 23) measured 5·2 mm. (stage O), and the largest was 17·1 mm. (stage II). The size-range and frequency of the developmental stages were as follows :

Stage	Size-range (mm.)	Number
O	5·2–10·8	9
I	7·3–15·0	48
II	7·3–17·1	56
III	11·5–16·5	20
IV	8·1, 15·0	2

The great size-range of each stage can, in the case of *S. enflata*, be explained by the fact that individuals of this species may breed several times, and continue to grow all the time (see Furnestin, 1957, p. 226).

Other specifications, which agree with previous accounts, are as follows :

Sagitta enflata

Length				Tail (% length)				Hooks				Anterior teeth			Posteri		
mm.	O, I	II–IV	Total	%	O, I	II–IV	Total	No.	O, I	II–IV	Total	O, I	II–IV	Total	O, I	II–IV	Total
16–18	—	6	**6**	*13*	—	4	**4**	*5*	—	—	—	6	2	**8**	—	—	—
14–16	2	21	**23**	*14*	2	4	**6**	*6*	—	—	—	1	7	**8**	1	—	**1**
12–14	11	35	**46**	*15*	7	12	**19**	*7*	—	1	**1**	5	9	**14**	1	—	**1**
10–12	20	12	**32**	*16*	9	22	**31**	*8*	—	4	**4**	17	15	**32**	—	—	—
8–10	14	4	**18**	*17*	17	14	**31**	*9*	30	32	**62**	21	28	**49**	3	—	**3**
6–8	8	1	**9**	*18*	7	8	**15**	*10*	19	34	**53**	6	13	**19**	6	5	**11**
4–6	1	—	**1**	*19*	6	7	**13**	*11*	7	6	**13**	—	4	**4**	3	3	**6**
				20	4	2	**6**	*12*	—	2	**2**	—	1	**1**	8	11	**19**
				21	3	3	**6**	*13*	—	—	—				8	12	**20**
				22	—	3	**3**	*14*	—	—	—				15	18	**33**
				23	—	—	—	*15*	—	—	—				4	7	**11**
				24	1	—	**1**	*16*	—	—	—				6	9	**15**
								17	—	—	—				1	8	**9**
								18	—	—	—				—	5	**5**
								19	—	—	—				—	1	**1**

Sagitta zetesios Fowler and ***Sagitta planctonis*** Steinhaus

David, 1956.

These two species were for many years placed together as *S. planctonis*, but the definitive paper by David (1956) shows that they are separate, and that *S. zetesios* is much the commoner of the two. The best character for separating them is the number of posterior teeth in almost all specimens except juveniles ; *S. planctonis* has less than 14, *S. zetesios* has more than 14. Further, in a summary of previous records, David states that *S. planctonis* is epiplanktonic in warm water, whereas *S. zetesios* is mesoplanktonic in most deep oceans except the Antarctic. The *Rosaura* specimens fully confirm David in the matter of posterior teeth and as regards abundance and horizontal distribution (*S. zetesios* occurred in Stations 8 and 13 and in all but two of the offshore tropical stations, *S. planctonis* only in Stations 45 and 46 in the eastern central Atlantic). Because open nets were used, however, the *Rosaura* material does not provide evidence about vertical distribution.

David (1956) describes a third species from this group (*S. marri*) which is confined to the Antarctic, and it is perhaps worth calling attention to the remarkable parallelism in geographical distribution between this group of species and the group

S. maxima-lyra-gazellae. Each group contains one species which is almost cosmopolitan (*S. zetesios* and *S. maxima*), one confined to the Antarctic (*S. marri* and *S. gazellae*), and one confined to warmer waters (*S. planctonis* and *S. lyra*.)

S. zetesios. *Length* (see tables below). The 15 specimens of *S. zetesios* from Station 8 were well preserved and very large, ranging from 31 to 42·5 mm. (David (1956) says "*Length* up to 40 mm."). The tropical specimens were all contracted and the largest (stage II) was only 24·3 mm. long; I doubt whether any of the tropical ones could have been more than about 30 mm. long when alive. Part of this discrepancy can be explained by the greater age and maturity of the Greenland specimens, but even so stage I in Station 8 reached a size of 33 mm. The few specimens from Station 13 were intermediate as regards length.

Tail length. Those from Station 8 show a very narrow range of variation, all but three having tails 22 or 23% of the body-length. The much greater variation from the warmer stations is probably due to independently different degrees of contraction of trunk and tail.

Hooks. Station 8 shows fewer hooks (6–9) than the others (8–11). This may be an indication of racial difference, but David (in a letter) suggests that it is more likely due to the greater immaturity of the tropical specimens; it is difficult, however, on the latter supposition to explain away the several tropical stage II with 10 hooks, while no stage I from Station 8 had more than 9. The absence of stage O from Station 8 seems to be real. Had they been present they would have been in the same size-group as *Eukrohnia hamata*, of which I picked out 139 from Station 8.

Anterior teeth. Here I think that the difference between Station 8 and the others is due solely to the maturest specimens (of which there were none from the tropics) having shed several teeth in the manner of *S. maxima* and *S. lyra*.

Posterior teeth. There seems to be no significant difference between Station 8 and the others.

S. planctonis. *Length and maturity*. In length *S. planctonis* was very similar to the tropical *S. zetesios* and was about as contracted, but the largest specimens were much more mature. There was only one stage III *S. zetesios* in Stations 13–46, a rather small specimen of 18·3 mm.; the older ones were probably living below the depth fished by the nets. The epiplanktonic *S. planctonis*, on the other hand, provided six fully matured stage III, three each of stages I and II, and no stage O.

Tail length. This covers much the same range of variation as in the tropical *S. zetesios*.

Hooks. David (1956) says "*Hooks* up to 11, usually 8–11". The few *Rosaura* specimens have 6–9, mostly 7.

Anterior teeth. There are fewer anterior teeth (5–7, mostly 5) in *S. planctonis* than in the tropical *S. zetesios* (7–13, mostly 8–11).

Posterior teeth. With the exception of a single very small (6·2 mm.) *S. zetesios* with only 10 teeth, there is here an absolute distinction (confirming David, 1956) between the two species. In the *Rosaura* specimens *S. zetesios* have 12 posterior teeth or more, *S. planctonis* have 10 or less.

The size-range and frequency of occurrence of maturity stages of these two species were as follows :

	Sagitta zetesios						*S. planctonis*	
	Station 8		Station 13		Stations 27–46		Stations 45, 46	
Stage	Size-range (mm.)	No.	Size-range (mm.)	No.	Size-range (mm.)	No.	Size-range (mm.)	No.
O	—	0	22	1	8·9–17·0	5	—	0
I	31–33	7	—	—	6·2–20·5	33	9·7–18·4	3
II	32·5–38	6	24–28·5	4	9·2–24·3	25	17·2–17·7	3
III	40, 42·5	2	—	—	18·3	1	18·9–26·9	6

Other specifications were as follows (*S. zetesios* on the left, *S. planctonis* on the right) :

	Sagitta zetesios									*S. planctonis*		
	Station 8			Station 13			Stations 27–46			Stations 45, 46		
Length (mm.)	I	II, III	Total	O	II	Total	O, I	II, III	Total	I	II, III	Total
40–44	—	2	**2**	—	—	—	—	—	—	—	—	—
36–40	—	5	**5**	—	—	—	—	—	—	—	—	—
32–36	4	1	**5**	—	—	—	—	—	—	—	—	—
28–32	3	—	**3**	—	1	**1**	—	—	—	—	—	—
24–28	—	—	—	—	3	**3**	—	1	**1**	—	1	**1**
20–24	—	—	—	1	—	**1**	2	5	**7**	—	3	**3**
16–20	—	—	—	—	—	—	6	12	**18**	1	5	**6**
12–16	—	—	—	—	—	—	16	7	**23**	1	—	**1**
8–12	—	—	—	—	—	—	13	1	**14**	1	—	**1**
4–8	—	—	—	—	—	—	1	—	**1**			

Tail (as % of length)

	S. zetesios						*S. planctonis*		
	Station 8			Stations 13–46			Stations 45, 46		
%	I	II, III	Total	O, I	II, III	Total	I	II, III	Total
17	—	—	—	3	2	**5**	—	2	**2**
18	—	—	—	8	3	**11**	—	1	**1**
19	—	—	—	5	4	**9**	—	—	—
20	—	—	—	9	6	**15**	—	4	**4**
21	1	1	**2**	3	5	**8**	1	1	**2**
22	3	4	**7**	3	5	**8**	1	1	**2**
23	3	2	**5**	2	1	**3**	—	—	—
24	—	1	**1**	3	1	**4**	1	—	**1**
25	—	—	—	3	2	**5**			
26	—	—	—	—	1	**1**			

Hooks

	S. zetesios						*S. planctonis*		
	Station 8			Stations 13–46			Stations 45, 46		
No.	I	II, III	Total	O, I	II, III	Total	I	II, III	Total
6	—	1	**1**	—	—	—	—	1	**1**
7	—	3	**3**	—	—	—	—	7	**7**
8	3	3	**6**	—	4	**4**	—	1	**1**
9	4	1	**5**	15	17	**32**	3	—	**3**
10	—	—	—	22	9	**31**			
11	—	—	—	2	—	**2**			

Anterior teeth

	S. zetesios						*S. planctonis*		
	Station 8			Stations 13–46			Stations 45, 46		
No.	I	II, III	Total	O, I	II, III	Total	I	II, III	Total
4	—	1	**1**	—	—	—	—	—	—
5	—	1	**1**	—	—	—	—	7	**7**
6	—	1	**1**	—	—	—	2	1	**3**
7	1	1	**2**	2	—	**2**	1	1	**2**
8	—	3	**3**	11	5	**16**			
9	1	—	**1**	6	5	**11**			
10	3	—	**3**	15	8	**23**			
11	2	1	**3**	2	8	**10**			
12	—	—	—	2	1	**3**			
13	—	—	—	1	3	**4**			

Posterior teeth

	S. zetesios						*S. planctonis*		
	Station 8			Stations 13–46			Stations 45, 46		
No.	I	II, III	Total	O, I	II, III	Total	I	II, III	Total
5	—	—	—	—	—	—	—	1	**1**
6	—	—	—	—	—	—	—	3	**3**
7	—	—	—	—	—	—	—	—	—
8	—	—	—	—	—	—	1	4	**5**
9	—	—	—	—	—	—	1	1	**2**
10	—	—	—	1	—	**1**	1	—	**1**
11	—	—	—	—	—	—			
12	—	1	**1**	1	—	**1**			
13	—	3	**3**	2	—	**2**			
14	—	1	**1**	3	—	**3**			
15	—	—	—	2	1	**3**			
16	4	—	**4**	7	3	**10**			
17	—	1	**1**	3	3	**6**			
18	3	2	**5**	4	5	**9**			
19	—	—	—	4	9	**13**			
20	—	—	—	9	5	**14**			
21	—	—	—	2	2	**4**			
22	—	—	—	1	2	**3**			

Sagitta neglecta Aida

Fowler, 1906 : 15.
Ritter-Záhony, 1911 : 23.
Michael, 1911 : 46 ; 1919 : 258.
Thomson, 1947 : 17.

There were seven specimens from five tropical stations (15, 23, 27 and 28 in the Caribbean, 46 in the eastern Central Atlantic).

Length (mm.)	Tail (% length)	Hooks	Ant. teeth	Post. teeth	Stage
8·8	25	10	6	12	III
8·3	24	7	8	18	II
7·2	25	7	8	13	II
7·2	26	8	5	14	I
7·0	27	7	6	11	I
6·5	22	6	8	13	I
6·2	31	7	3	9	O

Sagitta pulchra Doncaster

Fowler, 1906 : 17.
Ritter-Záhony, 1911 : 21.
Michael, 1919 : 251.
Thomson, 1947 : 19.

There were only two specimens, both from Station 42 off north-east Brazil.

Length (mm.)	Tail (% length)	Hooks	Ant. teeth	Post. teeth	Stage
9·6	22	5	8	16	III
8·5	24	6	7	16	II

Sagitta macrocephala Fowler

Fowler, 1905 : 65.
Ritter-Záhony, 1911 : 30.
Fraser, 1952 : 10.

This species is very easy to recognize, even with the naked eye, by its red colour and its large head. It is a deep-water species, and provided 107 specimens. It occurred off Greenland (Station 8), off the eastern United States (Station 13), in the Tongue of the Ocean in the Bahamas (Station 14), in two of the deepest hauls in the Caribbean (Stations 28 and 33), and in two of the deepest hauls in the central Atlantic (Stations 42 and 46). It was not picked out from the deep haul between Cuba and Jamaica (Station 15) ; two other regularly occurring species, *S. maxima* and *S. zetesios*, were also missing from Station 15.

The 19 specimens from Station 8 were well preserved and ranged in size from 12·5 to 21 mm. Those from other stations were badly contracted, and did not exceed 12·8 mm. The size-range (for what it is worth) and the frequency of maturity stages were as follows :

Stage	Size-range (mm.)	Number
O	5·2–11·6	20
I	5·15–19·0	60
II	8·1–21·0	25
III	20·5	1

Other specifications are shown below; *S. macrocephala* is remarkable for the even spread of the numbers of both sets of teeth in the adults, and for the range of numbers.

Sagitta macrocephala

Length				Tail (% length)				Hooks				Anterior teeth			Posterior teeth			
mm.	O, I	II, III	Total	%	O, I	II, III	Total	No.	O, I	II, III	Total	O, I	II, III	Total	No.	O, I	II, III	Total
20–22	—	3	3	26	1	—	1	1	—	—	—	1	—	1	16–18	6	—	6
18–20	1	3	4	27	2	—	2	—	—	—	—	—	—	—	19	3	—	3
16–18	—	—	0	28	4	1	5	4	—	—	—	—	1	1	20	5	—	5
14–16	7	1	8	29	5	1	6	5	—	—	—	3	2	5	21	9	—	9
12–14	7	2	9	30	5	3	8	6	—	—	—	14	3	17	22	4	—	4
10–12	5	7	12	31	7	2	9	7	—	—	—	35	8	43	23	3	1	4
8–10	18	10	28	32	16	1	17	8	—	—	—	14	4	18	24	8	3	11
6–8	34	—	34	33	11	6	17	9	—	—	—	9	5	14	25	4	2	6
4–6	8	—	8	34	7	3	10	10	—	1	1	3	3	6	26	8	—	8
				35	8	2	10	11	16	4	20				27	7	2	9
				36	5	1	6	12	44	14	58				28	5	4	9
				37	5	1	6	13	20	7	27				29	8	4	12
				38	3	2	5								30	3	1	4
				39	1	1	2								31	2	1	3
				40	—	2	2								32	1	2	3
															33	1	2	3
															34	2	2	4
															35	—	1	1
															37	—	1	1

Pterosagitta draco (Krohn)

Ritter-Záhony, 1911: 33.
Michael, 1919: 264.
Ghirardelli, 1950: 121.
Furnestin, 1957: 246.

This small, easily recognized species was taken in small numbers at almost every station in the Caribbean and central Atlantic. According to Burfield & Harvey (1926) and Thomson (1947) it lives mainly near the surface; accordingly it would have beeen encountered by the *Rosaura*'s nets only during the last few minutes of each haul, and in any case it is too small to be caught reliably by a stramin net. These considerations indicate, I think, that *P. draco* must be common or abundant throughout the tropical waters sampled by the *Rosaura*.

Burfield & Harvey (1926) record *P. draco* as abundant in the Indian Ocean, Burfield (1930) as abundant in the central Atlantic, Tokioka (1939, 1940*a*) as common in the warmer waters off Japan, Thomson (1947) as common to the south-east of Australia, and Pierce (1953) as common off North Carolina. Nevertheless Furnestin (1957) states: "les auteurs s'accordent à signaler sa rarété, non seulement en Méditerranée mais aussi dans l'Atlantique et le Pacifique (exception faite pour Thomson, qui la classe parmi les espèces 'sub-dominantes' au sud-est de l'Australie."

There are 45 specimens in the *Rosaura* collection, ranging in size from 4·4 mm. (stage II) to 7·8 mm. (stage III); many of them are rather contracted. The size-range and frequency of occurrence of the maturity stages are as follows:

Stage	Size-range (mm.)	Number
O	4·5, 4·7	2
I	4·85–6·25	8
II	4·4–7·45	14
III	5·5–7·8	18
IV	5·4, 6·5, 7·0	3

Other specifications are as follows :

Length		Tail (% length)		Hooks		Ant. teeth		Post. teeth	
mm.	Total	%	Total	No.	Total	No.	Total	No.	Total
7–8	**11**	*31–38*	**5**	*8*	**2**	*6*	**11**	*10–13*	**3**
6–7	**17**	*39*	**4**	*9*	**10**	*7*	**13**	*14*	**9**
5–6	**13**	*40*	**15**	*10*	**28**	*8*	**16**	*15*	**10**
4–5	**4**	*41*	**5**	*11*	**4**	*9*	**4**	*16*	**8**
		42	**5**	*12*	**1**			*17*	**6**
		43	**5**					*18*	**7**
		44	**3**					*19*	**1**
		45–47	**3**					*22*	**1**

Krohnitta subtilis (Grassi)

Michael, 1911 : 52.
Tokioka, 1939 : 135.
Thomson, 1947 : 22.
Vannucci & Hosoe, 1952 : 25.

The 11 specimens of this very slender species were all from tropical stations. Several authors have attempted to join *K. pacifica* with this species, but the descriptions of Tokioka (1939) and Thomson (1947), make it certain that the two species are distinct. Dr. Pierce kindly sent me a sample of his Floridan *K. pacifica,* which was a great help in confirming that all the *Rosaura* specimens do belong to *K. subtilis.* This is of some interest, in that both Tokioka in Japanese waters, and Pierce (1951, 1953) off Florida and North Carolina, stress the comparative scarcity of *K. subtilis* as compared with *K. pacifica.*

The details of the *Rosaura* specimens were as follows (there is only one row of teeth in *Krohnitta*) :

Length (mm.)	Tail (% length)	Hooks	Teeth	Stage
11·8	36	8	11	II
11·3	33	8	11	II
10·7	34	9	12	III
10·7	38	9	10	II
10·6	32	9	12	III
10·6	38	9	10	III
10·0	35	8	10	III
10·0	33	9	11	III
9·8	33	8	12	II
9·25	39	8	10	II
9·0	36	9	9	O

Eukrohnia hamata (Möbius)

Ritter-Záhony, 1910*a* : 268 ; 1911 : 39.
Michael, 1911 : 39.
Fraser, 1952 : 10.

As recently as 1947 Thomson stated that *E. fowleri* was synonymous with *E. hamata*, but there can be no doubt that, as most authors have maintained, the two species are separate. In *E. hamata* the eyes usually lack black pigment, the gut is not as a rule coloured red, and few, if any, have more than 11 hooks. In *E. fowleri* the eyes have a conspicuous patch of black pigment, the gut is a bright red, and few, if any, have fewer than 12 hooks. It seems probable that Thomson did not have any *E. fowleri* (a deep-living species) in his material.

As has been mentioned earlier, the *Rosaura* chaetognaths were sorted immediately after capture into red and colourless forms, and this served to separate 275 red *E. fowleri* from 204 *E. hamata* with only a single doubtful case. All the *E. hamata* had 7, 8, 9 or 10 hooks, whereas all but one of the *E. fowleri* had 12, 13 or 14 ; the exception was a very small (7·5 mm., stage O) *E. fowleri* with only 10 hooks, but this individual was too young to have developed its full complement of hooks and so does not affect the argument. *Not a single one of either species had* 11 *hooks on either side.*

There were 204 specimens of *E. hamata*, of which 139 were in the sample off Greenland (Station 8) agreeing with Kramp (1939) who found *E. hamata* abundant in these waters. It was again the most abundant chaetognath from Station 13 off the eastern United States, but after that there were only one between Cuba and Jamaica (Station 15), seven off NE. Brazil (Station 42) and six south-west of Dakar (Station 46), these last three being relatively deep tropical hauls. I found none in the Caribbean Sea. *E. hamata* has been recorded at the surface in both northern and southern high latitudes, but in low latitudes only at depths where the temperature stays below about 12° C. (Fowler, 1906 ; Ritter-Záhony, 1911 ; Johnston & Taylor, 1921 ; Burfield & Harvey, 1926 ; Burfield, 1930 ; Kramp, 1939 ; Thomson, 1947).

In *Eukrohnia*, in contrast to *Sagitta*, " spents " are not uncommon in which the ovaries remain visible as shrunken remnants ; following Kramp (1939) I have classified these " spents " as stage V.

As in the case of *Sagitta maxima* (q.v.) there seems to be some correlation between size and latitude. In Station 8 (off Greenland) the largest specimen measured 34 mm., in Station 13 (off the eastern United States) 25·2 mm., and in the tropical stations 16·1 mm. The tropical specimens were somewhat more contracted than the others, but never so much so as to make it possible that they were as large when alive.

The size-range and frequency of occurrence of the maturity stages were as follows :

	Station 8 (Arctic)		Station 13 (Temperate)		Stations 15, 42, 46 (Tropical)	
Stage	Size-range (mm.)	No.	Size-range (mm.)	No.	Size-range (mm.)	No.
O	9·5–19·5	21	11·2–23·0	12	—	—
I	16·5–27·5	25	10·7–24·5	25	7·2	1
II	20·0–31·0	52	18·7–24·2	9	9·4, 16·1	2
III	17·0–29·0	18	21·8–25·1	4	8·8–11·2	3
IV	20·5–34·0	18	—	—	9·5	1
V	20·5–29·0	5	25·2	1	13·3	1

Other specifications are shown below. (As with *Krohnitta*, *Eukrohnia* possesses only one row of teeth, but whereas those of *Krohnitta* appear to be homologous with the anterior teeth of *Sagitta*, those of *Eukrohnia* are clearly homologous with the posterior teeth of *Sagitta*.)

Eukrohnia hamata

Length				Tail (% of length)				Hooks				Teeth			
mm.	O, I	II–V	Total	%	O, I	II–V	Total	No.	O, I	II–V	Total	No.	O, I	II–V	Total
32–36	—	1	**1**	20	1	—	**1**	7	—	1	**1**	3–9	14	1	**15**
28–32	—	16	**16**	21	4	3	**7**	8	19	17	**36**	10	3	1	[illegible]
24–28	23	49	**72**	22	7	7	**14**	9	58	87	**146**	11	4	1	**5**
20–24	13	39	**52**	23	7	10	**17**	10	7	9	**16**	12	5	—	**5**
16–20	21	3	**24**	24	7	14	**21**					13	2	1	**3**
12–16	20	1	**21**	25	8	6	**14**					14	1	—	**1**
8–12	6	5	**11**	26	11	13	**24**					15	4	1	**5**
4–8	1	—	**1**	27	6	14	**20**					16	—	3	**3**
				28	9	18	**27**					17	1	5	**6**
				29	7	18	**25**					18	9	18	**27**
				30	5	3	**8**					19	13	18	**31**
				31	6	4	**10**					20	12	15	**27**
				32	3	1	**4**					21	3	15	**18**
				33	2	2	**4**					22	7	17	**24**
				34	1	—	**1**					23	1	12	**13**
				35	—	1	**1**					24	2	3	**5**
												25–28	3	3	**6**

Eukrohnia fowleri Ritter-Záhony

Ritter-Záhony, 1911 : 40.
Fraser, 1952 : 10.

The three main criteria for separating *E. fowleri* from *E. hamata* (colour, number of hooks, eye pigment) have been discussed above in the section on *E. hamata*.

Both species occurred together in several of the *Rosaura* hauls, but their relative abundance varied greatly. In the two most northerly stations (8 and 13) *E. fowleri* was much less abundant than *E. hamata*, but in the tropical stations it was much more so, and was, indeed, the commonest chaetognath in several of the samples. It was not found in every tropical haul, being absent from those where the estimated depth of the net was less than 900 m., and common only when the net went deeper than 1,000 m. *E. fowleri* is widely recognized as an inhabitant of considerable depths; in this respect it resembles the other red species, *Sagitta macrocephala*, whose incidence in the *Rosaura* collection was strikingly similar.

As in the case of *E. hamata*, *E. fowleri* reached a larger size in higher latitudes than in the tropics, but the difference was not so marked.

There were altogether 275 specimens of *E. fowleri*, of which all but 20 were caught in the tropics. The smallest was the 7·5 mm. juvenile with but 10 hooks already mentioned (p. 248) from the Gulf of Honduras (Station 28), and the largest measured 29·5 (stage I, Station 8).

The size-range and frequency of occurrence of the maturity stages were as follows :

Stage	Stations 8 and 13 (Arctic and Temperate) Size-range (mm.)	Tropical stations Size-range (mm.)	Total number
O	—	7·5–10·8	5
I	16·9–29·5	8·2–21·2	114
II	25·2–28·0	14·3–23·0	67
III	24·2–28·7	17·6–24·7	36
IV	—	18·0–21·6	5
V	27·0	17·6–27·8	38

Other specifications were as follows :

Eukrohnia fowleri

Length				Tail (% length)				Hooks				Teeth			
mm.	O, I	II–V	Total	%	O, I	II–V	Total	No.	O, I	II–V	Total	No.	O, I	II–V	Total
28–32	2	3	**5**	*17*	2	5	**7**	*10*	1	—	**1**	*10–15*	24	—	**24**
24–28	2	16	**18**	*18*	9	6	**15**	*11*	—	—	—	*16*	3	—	**3**
20–24	6	60	**66**	*19*	12	12	**24**	*12*	52	49	**102**	*17*	10	3	**13**
16–20	36	62	**98**	*20*	22	14	**36**	*13*	64	89	**153**	*18*	7	2	**9**
12–16	51	5	**56**	*21*	31	26	**57**	*14*	1	9	**10**	*19*	12	4	**16**
8–12	19	—	**19**	*22*	16	31	**47**					*20*	8	1	**9**
4–8	3	—	**3**	*23*	9	21	**30**					*21*	6	2	**8**
				24	10	9	**19**					*22*	16	11	**27**
				25	4	12	**16**					*23*	10	16	**26**
				26	2	4	**6**					*24*	10	18	**28**
				27	1	2	**3**					*25*	6	23	**29**
				28	1	3	**4**					*26*	4	24	**28**
				29	—	1	**1**					*27*	3	20	**23**
												28	—	11	**11**
												29	—	5	**5**
												30	—	5	**5**
												31	—	—	—
												32	—	2	**2**

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Summary of Tail-lengths and Head Armatures as Shown by the Great Majority of Adults (Stages II and up) in the Rosaura *Collection*

Species	Length (mm.)	Tail (as % length)	Hooks (No.)	Ant. teeth (No.)	Post. teeth (No.)
Sagitta friderici	12·7	26	8	8	18
S. tenuis	4–6	27–33	8, 9	4–7	10–14
S. bipunctata	6–12	24–28	8–10	6, 7	13–16
S. robusta	9–12	26	7	8–10	12
S. serratodentata	7–10	22–26	6, 7	8–10	15–22
S. lyra :					
Stages I, II	15–27	14–17	6–8	6–8	8–10
Stages III, IV			3		2, 3
S. maxima :					
Arctic	40–60	20–27	6–8	2–4	5–8
Tropics	16–35		3–5		2–5
S. hexaptera	16–36	18–23	6–9	2–4	1–4
S. decipiens	10–14	21–23	6, 7	6–8	13–16
S. enflata	7–17	13–20	9, 10	6–10	10–18
S. planctonis	16–25	17–22	7	5	6–8
S. zetesios :					
Arctic	32–44	21–24	7–9	4–11	12–18
Temperate and Tropics	10–28	17–25	8–10	8–13	15–22
S. neglecta	7–9	24, 25	7, 10	6, 8	12, 13, 18
S. pulchra	8–10	22, 24	5, 6	7, 8	16
S. macrocephala	8–22	30–40	11–13	5–10	24–34
Pterosagitta draco	4–8	39–44	9–11	6–9	14–18
Krohnitta subtilis	9–12	32–39	8, 9	10–12	—
Eukrohnia hamata	12–32	22–29	8–10	—	16–24
E. fowleri	12–32	17–26	12–14	—	22–30

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(* Not seen.)

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